CLAIMS

1.   A method of detecting surface particulate defects, and especially metal
particulates, in semiconductors such as silicon, to characterise defects likely to
have an effect on the electrical activity of such semiconductor materials,
comprises the steps of:

exposing the surface of the semiconductor structure in the vicinity of a surface
particulate to at least one high-intensity beam of light from a suitable light
source;

collecting photoluminescence produced by excitation of the semiconductor
structure by the light beam;

processing the collected photoluminescence to produce a result representative
of the intensity of the photoluminescence response;

comparing the result with a predetermined acceptable specification range of
photoluminescence to identify unacceptable contamination levels resulting
from diffusion of contaminant from particulate into semiconductor structure.

2.   A method in accordance with claim 1 as a method of quality control
comprising a further step of making a quality classification of the
semiconductor structure based upon such a comparison, and rejecting or
selecting for remedial action semiconductor structures exhibiting a
photoluminescence response outside the said predetermined acceptable
specification range.

3.   A method in accordance with claim 1 or claim 2 further comprising a
prior step of determining a predetermined acceptable specification from
studies of samples of fabricated devices using electrical yield test methods.

4.   A method in accordance with any preceding claim wherein the semiconductor is annealed prior to carrying out the detection steps to diffuse contaminant from the particle into the semiconductor material and make detection easier.

5.   A method in accordance with claim 4 wherein the detection steps are repeated prior to and subsequent to an annealing step and the results compared to determine the difference and obtain an indication of rates of diffusion so as to identify the contaminant.

6.   A method of detecting surface particulate defects, and especially metal particulates, in semiconductors such as silicon, to characterise defects likely to have an effect on the electrical activity of such semiconductor materials, comprises:

a first step of collecting photoluminescence by:

exposing the surface of the semiconductor structure in the vicinity of a surface particulate to at least one high-intensity beam of light from a suitable light source;

collecting photoluminescence produced by excitation of the semiconductor structure by the light beam;

processing the collected photoluminescence to produce a first photoluminescence result representative of the intensity of the photoluminescence response;

a heating step to the semiconductor to diffuse contaminant from the particle into the semiconductor material;

a second step of collecting photoluminescence produced by like method to the first to produce a second photoluminescence result representative of the intensity of the photoluminescence response as above described after annealing;

a step of comparing the results of each photoluminescence step to determine the difference and obtain an indication of rates of diffusion so as to identify the contaminant.

5   7.   A method in accordance with any preceding claim wherein the light source is a high-intensity laser.

8.   A method in accordance with claim 7 wherein the spatial resolution of the laser is 0.1 to 20 µm.

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9.   A method in accordance with claim 7 or 8 wherein the laser provides a peak or average power density of between 10^4 to 10^9 watts/cm^2.

10.   A method in accordance with any preceding claim wherein the light

15   beam used to generate the PL effect is so controlled as to collect PL information from no deeper than the upper 12µm of the semiconductor structure.

11.   A method in accordance with any preceding claim comprising a first

20   step of locating surface particulates using a suitable particulate imaging method, and a subsequent or simultaneous second step of generating PL intensity information in accordance with any preceding claim from the vicinity of each particulate to provide a quantification of the extent to which contaminant has diffused from the particulate into the near-surface region of

25   the semiconductor.

12.   A method in accordance with claim 11 wherein the particulate imaging, mapping and locating method comprises the generation of a scattered light dark field image and/or a reflected light bright field image.

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13.   A method in accordance with claim 12 including the steps of:

directing a high intensity beam of light such as a high-intensity laser at a surface of a sample of semiconductor structure to be tested in the manner above described;

5   producing a first or photoluminescence image from photoluminescence produced by excitation of the semiconductor structure by the light beam;

producing a second image mapping the location of the particulates, either as a dark field image of light scattered from the surface of the semiconductor structure or as a bright field image of light reflected from the surface of the

10   semiconductor structure;

using the second image to detect and map surface particulates;

processing the photoluminescence image to produce a result representative of the intensity of the photoluminescence response of the semiconductor structure in the vicinity of the surface particulates so detected.

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14.   An apparatus for detecting surface particulate defects, and especially metal particulates, in semiconductors such as silicon, to characterise defects likely to have an effect on the electrical activity of such semiconductor materials, comprises a support for a semiconductor sample under test; a high

20   intensity light source; means to focus a high intensity beam of light from the light source onto a surface of a semiconductor sample under test on the support; collection means to collect photoluminescence data produced by excitation of the semiconductor structure by the light beam at least in the vicinity of particulates on the surface thereof; means to process the collected

25   data to produce a result representative of the intensity of the photoluminescence response in the said vicinity; a comparator to compare the result with a predetermined acceptable specification range of photoluminescence to identify unacceptable contamination levels resulting from diffusion of contaminant from particulate into semiconductor structure.

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15.   An apparatus in accordance with claim 14 further including means to heat the sample under test associated with the support.

16.   An apparatus for detecting surface particulate defects, and especially 5 metal particulates, in semiconductors such as silicon, to characterise defects likely to have an effect on the electrical activity of such semiconductor materials, comprises a support for a semiconductor sample under test; a high intensity light source; means to focus a high intensity beam of light from the light source onto a surface of a semiconductor sample under test on the 10 support; collection means to collect photoluminescence data produced by excitation of the semiconductor structure by the light beam at least in the vicinity of particulates on the surface thereof; means to process the collected data to produce a result representative of the intensity of the photoluminescence response in the said vicinity; heating means to heat the 15 sample in situ, allowing a photoluminescence response to be measured before and after heating, and a comparator to compare the said two photoluminescence responses to determine the difference and obtain an indication of rates of diffusion so as to identify the contaminant.

20 17.   An apparatus in accordance with claim 15 or claim 16 wherein the heating means comprises a heated stage.

18.   An apparatus in accordance with one of claims 15 to 17 further including imaging means to create an image map of the location of particulates 25 on the surface of the semiconductor structure.

19.   An apparatus in accordance with claim 18 wherein the imaging means generates a scattered light dark field image and/or a reflected light bright field image.